

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

- 47A
1. A kinetic spectrophotometer comprising:
    - (a) a light source; and
    - (b) a compound parabolic concentrator disposed to receive light from the light source and configured to (1) intensify and diffuse the light received from the light source, and (2) direct the intensified and diffused light onto a sample.
  2. A kinetic spectrophotometer of Claim 1 wherein the light source comprises a light emitting diode.
  3. A kinetic spectrophotometer of Claim 1 wherein the light source comprises a plurality of light emitting diodes.
  4. A kinetic spectrophotometer of Claim 1 wherein the compound parabolic concentrator is hollow.
  5. A kinetic spectrophotometer of Claim 1 wherein the compound parabolic concentrator is solid.
  6. A kinetic spectrophotometer of Claim 1 further comprising a second compound parabolic concentrator disposed to receive light that is transmitted through the sample, or that is emitted by the sample, and that is configured to (1) collimate the received light, and (2) emit the collimated light.
  7. A kinetic spectrophotometer of Claim 6 wherein the second compound parabolic concentrator is hollow.
  8. A kinetic spectrophotometer of Claim 6 wherein the second compound parabolic concentrator is solid.
  9. A kinetic spectrophotometer of Claim 6 further comprising a third compound parabolic concentrator disposed to receive light emitted from the second compound parabolic concentrator and that is configured to (1) intensify and diffuse the light received from the second compound parabolic concentrator, and (2) direct the intensified and diffused light onto a light detector.

10. A kinetic spectrophotometer of Claim 9 wherein the third compound parabolic concentrator is hollow.

11. A kinetic spectrophotometer of Claim 9 wherein the third compound parabolic concentrator is solid.

12. A kinetic spectrophotometer of Claim 9 wherein the light detector comprises a photodiode.

13. A kinetic spectrophotometer of Claim 9 further comprising a filter disposed between the second and third compound parabolic concentrators, the filter being adapted to block a portion of the light emitted from the second compound parabolic concentrator.

14. A kinetic spectrophotometer comprising:

(a) a light source;

(b) a compound parabolic concentrator comprising an entry aperture, defining an entry aperture area, and an exit aperture, defining an exit aperture area, wherein the compound parabolic concentrator is:

(1) disposed to receive light from the light source through the entry aperture; and

(2) is configured to intensify and diffuse the light received from the light source, and to direct the intensified and diffused light, through the exit aperture, onto a sample;

wherein the entry aperture area is larger than the exit aperture area;

(c) a second compound parabolic concentrator comprising an entry aperture, defining an entry aperture area, and an exit aperture, defining an exit aperture area, wherein the second compound parabolic concentrator is:

(1) disposed to receive, through the entry aperture, light that is transmitted through the sample, or that is emitted by the sample; and

(2) that is configured to collimate the received light, and to emit the collimated light through the exit aperture onto a filter;

wherein the second compound parabolic concentrator entry aperture area is smaller than the second compound parabolic concentrator exit aperture area;

(d) a filter disposed to receive light that is emitted from the second compound parabolic concentrator exit aperture, and that is adapted to block a portion of the light emitted from the second compound parabolic concentrator; and

(e) a third compound parabolic concentrator comprising an entry aperture, defining an entry aperture area, and an exit aperture, defining an exit aperture area, wherein the second compound parabolic concentrator is:

(1) disposed to receive, through the entry aperture, light that passes through the filter; and

(2) that is configured to intensify and diffuse the light received from the filter, and to direct the intensified and diffused light onto a light detector;

wherein the third compound parabolic concentrator entry aperture area is larger than the third compound parabolic concentrator exit aperture area.

15. A method for measuring a photosynthetic parameter comprising:

(a) illuminating a plant leaf until steady-state photosynthesis is achieved;

(b) subjecting the illuminated plant leaf to a period of darkness;

(c) using a kinetic spectrophotometer of Claim 1 or Claim 14 to collect spectral data from the plant leaf treated in accordance with steps (a) and (b); and

(d) determining a value for a photosynthetic parameter from the spectral data.

16. A method for measuring a photosynthetic parameter of Claim 15 which uses a kinetic spectrophotometer of Claim 14.

17. A method for measuring a photosynthetic parameter of Claim 15 which uses a kinetic spectrophotometer of Claim 1.

18. A method of Claim 15 wherein the plant leaf is subjected to darkness for a period of time from 2 milliseconds to 120 seconds.

19. The method of Claim 15 wherein the determined photosynthetic parameter is electron transfer through photosystem I.

20. The method of Claim 19 wherein the spectral data is collected from the plant leaf by a method comprising illuminating the plant leaf with a measuring beam of light having a wavelength of 820 nm.

21. The method of Claim 15 wherein the determined photosynthetic parameter is the electrochromic shift.

22. The method of Claim 21 wherein the spectral data is collected from the plant leaf by a method comprising illuminating the plant leaf with a measuring beam of light having a wavelength of 525 nm.

23. The method of Claim 15 wherein the determined photosynthetic parameter is chlorophyll a fluorescence.

24. The method of Claim 23 wherein the spectral data is collected from the plant leaf by a method comprising illuminating the plant leaf with a measuring beam of light having a wavelength of 644 nm.

25. The method of Claim 15 further comprising the step of using the determined value for the photosynthetic parameter to determine the physiological state of a plant.

26. The method of Claim 25 wherein the step of using the determined value for the photosynthetic parameter to determine the physiological state of a plant comprises the step of comparing the determined value for the photosynthetic parameter to a reference value for the same photosynthetic parameter determined from spectral data obtained from one or more reference plants.

27. The method of Claim 26 further comprising the step of observing a difference between the determined value for the photosynthetic parameter and the reference value for the photosynthetic parameter.

28. The method of Claim 27 further comprising the step of correlating the difference between the determined value for the photosynthetic parameter and the reference value for the photosynthetic parameter with the presence of a physiological stress in the plant.

29. The method of Claim 28 wherein:

- (a) the photosynthetic parameter is electron transfer through photosystem I;
- (b) the determined value for electron transfer through photosystem I is greater than the reference value for electron transfer through photosystem I; and
- (c) the difference between the determined value for electron transfer through photosystem I and the reference value for electron transfer through photosystem I is correlated with the presence of heat stress in the plant.

30. The method of Claim 28 wherein:

- (a) the photosynthetic parameter is the electrochromic shift;
- (b) the determined value for the electrochromic shift is greater than the reference value for the electrochromic shift; and
- (c) the difference between the determined value for the electrochromic shift and the reference value for the electrochromic shift is correlated with the presence of heat stress in the plant.

31. The method of Claim 28 wherein:

- (a) the photosynthetic parameter is chlorophyll a fluorescence;
- (b) the determined value for chlorophyll a fluorescence is greater than the reference value for chlorophyll a fluorescence; and
- (c) the difference between the determined value for chlorophyll a fluorescence and the reference value for chlorophyll a fluorescence is correlated with the presence of heat stress in the plant.

32. The method of Claim 28 wherein:

- (a) the photosynthetic parameter is the ratio of the amplitudes of 820 nm absorbance and 525 nm absorbance;
- (b) the determined value for said ratio is greater than the reference value for said ratio; and
- (c) the difference between the determined value for said ratio and the reference value for said ratio is correlated with the presence of drought stress in the plant.